

## CHLORINE

Chlorine is a federal hazardous air pollutant and was identified as a toxic air contaminant in April 1993 under AB 2728.

CAS Registry Number: 7782-50-5

Cl<sub>2</sub>

Molecular Formula: Cl<sub>2</sub>

Chlorine occurs as a greenish-yellow diatomic gas, a liquid, or in rhombic crystals. The odor is suffocating and very irritating by inhalation. Chlorine is soluble in water, alcohols, and alkalis. It is a powerful oxidizing agent, strongly electronegative, very reactive, and combines readily with all elements except the rare gases (xenon excluded) and nitrogen. Chlorine also acts as an electron-acceptor in forming complexes with many donor species. Monatomic chlorine is unstable under ordinary conditions and can be formed as a result of thermal or optical dissociation, by an electrical discharge, or as an intermediate during chemical reactions. Chlorine is marketed in the form of gas over liquid compressed into steel cylinders (Merck, 1989).

### Physical Properties of Chlorine

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Synonyms: bertholite; molecular chlorine

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|---------------------------|--|
| Molecular Weight:         | 70.906                                     |
| Boiling Point:            | -34.6 °C                                   |
| Melting Point:            | -100.98 °C                                 |
| Vapor Density:            | 2.5 (air = 1 at boiling point of chlorine) |
| Density/Specific Gravity: | 1.4085 at 20/4 °C                          |
| Vapor Pressure:           | 5 atm at 10.3 °C                           |
| Conversion Factor:        | 1 ppm = 2.9 mg/m <sup>3</sup>              |

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(HSDB, 1991; Merck, 1989; U.S. EPA, 1994a)

## SOURCES AND EMISSIONS

### A. Sources

Chlorine is used in the manufacture of chlorinated organic chemicals, plastics, and chlorinated lime. Other sources include water purification, shrinkproofing wool, in flame-retardant compounds and batteries, processing of some foods, metal fluxing, as a bleaching agent, in pulp and paper manufacturing, and detinning and dezincing iron (Sax, 1987; HSDB, 1991).

Chlorine is registered for use as a disinfectant. It is used as a post-harvest disinfectant for fruits and vegetables, or as a disinfectant in human drinking water treatment systems, swimming pool water systems, industrial ponds, and sewage systems. Chlorine may also be used as an algaecide in commercial and industrial water cooling tower systems (DPR, 1996).

The licensing and regulation of pesticides for sale and use in California are the responsibility of the Department of Pesticide Regulation (DPR). Information presented in this fact sheet regarding the permitted pesticidal uses of chlorine has been collected from pesticide labels registered for use in California and from DPR's pesticide databases. This information reflects pesticide use and permitted uses in California as of October 15, 1996. For further information regarding the pesticidal uses of this compound, please contact the Pesticide Registration Branch of DPR (DPR, 1996).

The primary stationary sources that have reported emissions of chlorine in California are real estate operators and lessors services, college and university services, and crude petroleum and natural gas extraction (ARB, 1997b).

Chlorine has also been identified but not quantified in motor vehicle exhaust by the Air Resources Board (ARB) (ARB, 1991e).

#### B. Emissions

The total emissions of chlorine from stationary sources in California are estimated to be at least 370,000 pounds per year (ARB, 1997b).

#### C. Natural Occurrence

There are no known natural sources of gaseous chlorine. Elemental chlorine makes up approximately 0.0314 percent of the upper earth's crust. The crustal material contains chlorine mainly in the form of sodium, potassium, and manganese chlorides (HSDB, 1991). Chlorine is a component of the minerals halite, sylvite, and carnallite and occurs as the chloride ion in seawater (Sax, 1987).

### **AMBIENT CONCENTRATIONS**

Chlorine is routinely monitored by the statewide Air Resources Board air toxics network. The network's mean concentration of chlorine from January 1996 through December 1996 is estimated to be 1.6 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ) or 0.55 parts per billion (ARB, 1997c). A United States Environmental Protection Agency (U.S. EPA) study reports chlorine concentrations of approximately 0.001 parts per million (ppm) or  $2.9 \mu\text{g}/\text{m}^3$  around coastal areas, and ambient levels in metropolitan areas such as Cincinnati or Baltimore averaging 0.02 ppm or  $58 \mu\text{g}/\text{m}^3$  (HSDB, 1991).

## **INDOOR SOURCES AND CONCENTRATIONS**

No information about the indoor sources and concentrations of chlorine was found in the readily-available literature.

## **ATMOSPHERIC PERSISTENCE**

Chlorine absorbs in the ultraviolet and visible region of the solar spectrum (260 to 470 nanometers) and undergoes rapid photolysis in the atmosphere. The atmospheric half-life and lifetime of chlorine due to photolysis is estimated to be about 10 minutes and 14 minutes, respectively. The chlorine atoms produced will then react with organic compounds (mainly alkanes in polluted urban areas) to form hydrogen chloride (Atkinson, 1995).

## **AB 2588 RISK ASSESSMENT INFORMATION**

The Office of Environmental Health Hazard Assessment reviews risk assessments submitted under the Air Toxics “Hot Spots” Program (AB 2588). Of the risk assessments reviewed as of December 1996, for non-cancer effects, chlorine contributed to the total hazard index in 9 of the approximately 89 risk assessments reporting a total chronic hazard index greater than 1. Chlorine also contributed to the total hazard index in 28 of the approximately 107 risk assessments reporting a total acute hazard index greater than 1, and presented an individual acute hazard index greater than 1 in 6 of these risk assessments (OEHHA, 1996b).

## **HEALTH EFFECTS**

Probable routes of human exposure to chlorine are inhalation, ingestion, and dermal contact (HSDB, 1991).

Non-Cancer: Chlorine gas is converted to hydrochloric acid (HSDB, 1991). Low level exposure (less than 3 ppm) causes irritation of the eyes, nose, throat, respiratory tract, and lungs. High level exposure (greater than 30 ppm) causes chest pain, vomiting, toxic pneumonitis, pulmonary edema, and death (U.S. EPA, 1994a). High concentrations also act as an asphyxiant by causing cramps in the muscles of the larynx (choking) and swelling of the mucous membranes which lead to suffocation, nausea, vomiting, anxiety, and syncope (Sittig, 1991).

An acute non-cancer Reference Exposure Level (REL) of  $23 \mu\text{g}/\text{m}^3$  and a chronic REL of  $7.1 \mu\text{g}/\text{m}^3$  are listed for chlorine in the California Air Pollution Control Officers Association Air Toxics “Hot Spots” Program, Revised 1992 Risk Assessment Guidelines. The toxicological endpoint considered for chronic and acute toxicity is the respiratory system (CAPCOA, 1993). The U.S. EPA is currently reviewing toxicity data to derive a Reference Concentration (RfC) and an oral Reference Dose (RfD) for chlorine (U.S. EPA, 1994a).

Limited information is available on adverse developmental or reproductive effects of chlorine in humans or animals via inhalation exposure (U.S. EPA, 1994a).

Cancer: No information is available on human carcinogenicity from the inhalation of chlorine (U.S. EPA, 1994a). The International Agency for Research on Cancer and the U.S. EPA have not classified chlorine for carcinogenicity (IARC, 1987a; U.S. EPA, 1994a).